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Efficiently teaching engineering and technology students through effective college–industry partnerships

Shweta Chopra
Iowa State University, schopra@iastate.edu

Kimberly M. Deranek
Nova Southeastern University

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Instructors have a very important role in successfully establishing college–industry partnerships, which can be a challenging and time-consuming task. Such relationships are more difficult to establish when instructors are new to a particular region. This paper focuses on the best practices required to establish industrial partnerships, the importance of leveraging support systems available at instructors' academic institutions, and how to establish relationships with local professional organizations and industry partners.

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Efficiently teaching engineering and technology students through effective college–industry partnerships

Shweta Chopra[1], Kimberly M. Deranek[2]
[1]Department of Agricultural & Biosystems Engineering, Iowa State University/[2]H. Wayne Huizenga College of Business and Entrepreneurship, Nova Southeastern University

Abstract

Establishing college–industry collaboration is vital for the success of undergraduate students in engineering and technology programs. Engagement with local industry partners is essential to teach these students applied and hands-on concepts such as lean manufacturing and facility planning. Instructors are required to build meaningful relationships with industry partners so that students can benefit from active learning. Through industry partnerships, students have an opportunity to learn in various ways such as by visiting industrial sites, conducting projects with local industries, and having guest speakers discuss the numerous aspects of their business. Such activities help students become more immersed in their field of study, gain hands-on experience, and address real-world challenges as they transition from college to productive careers within industry.

Instructors have a very important role in successfully establishing college–industry partnerships, which can be a challenging and time-consuming task. Such relationships are more difficult to establish when instructors are new to a particular region. This paper focuses on the best practices required to establish industrial partnerships, the importance of leveraging support systems available at instructors' academic institutions, and how to establish relationships with local professional organizations and industry partners.

Introduction

Many engineering, technology, and business programs in higher education increase student knowledge about theoretical concepts using a multi-step process. First, theories are defined during concept introduction; then the introductory phase allows students an opportunity to apply those theories in practice.[1] The most common approach to theory delivery is in-class lecture. Although it is often difficult for students to comprehend all components presented during an extended class lecture, this method is still deemed a reliable and largely efficient way to teach. However, theory and practice has changed dramatically over the past few decades.[2] To maximize student learning, teaching methodology should not be limited to the classroom or even university boundaries. Instructors must facilitate learning beyond lectures, and students need to actively participate in the learning process. Active learning environments are created by engaging students in reading, writing, discussion, and/or problem solving methods to promote critical thinking.

Various studies have suggested that active learning helps enhance students' learning by improving their thinking and writing abilities.[3,4] Active learning also helps students foster information retention, critical thinking skills, and motivation to pursue higher education[5] and helps students critically analyze their learning outcomes and understand ways in which concepts can be applied in an industrial setting. Moreover, active learning helps students forge in-depth thinking regarding the course material and develop rational perspectives of what they have learned.[3] Students engaged in active learning feel much more involved in the educational process and are more satisfied with their learning outcomes. Active learners are more engaged in the classroom, making instructors feel more in command of the curriculum because of their ability to collectively identify problem areas.[4]

Traditional engineering, technology, and business programs in higher education focus on deductive methods of teaching. This methodology is used to help students derive mathematical models and learn model application. Model application is further achieved through the completion of homework assignments, and students are later tested for concept retention through some sort of assessment. This method doesn't use real-world approaches of dealing with problems.[1] Instead, students are provided an overview of why the course content is important, how it fits into the broad curriculum, and how it will apply to future applications in their careers; however, broad relevance is often not provided. College–industry collaboration can help bridge this gap between theory and real-world application.[6] Case studies based on real-world application, industry-based projects, guest speakers, and plant tours are some of the ways that college students get an opportunity to engage with industry stakeholders.

Industry-based learning helps students prepare for their future in the workforce and make informed decisions when they step into real-world positions.[2] Students in programs that are not restricted to classroom boundaries have been observed to have higher learning satisfaction and higher retention rates.[2] Students get a chance to see the relevance between their course curriculum and actual practice. Once hired, students who have interacted with industry personnel prior to graduation show less anxiety in their new roles and are able to perform task assignments more effectively.[7] Students are provided an opportunity to evaluate various organizational cultures and settings and are able to identify those that may best align with their career objectives. Industry-based student engagements help students practice their communication and teamwork skills, which are needed for industry success.

Anecdotal evidence suggests that students find it very useful to participate in industry collaboration during classroom projects. Industry collaboration has the potential to enhance students' ability to transition seamlessly from student status to a professional career. When students are provided opportunities to engage directly with industry partners, the end result is often a better-rounded graduate. Students foster a clearer understanding of how industry players operate and begin to appreciate professional expectations. This, combined with their academic knowledge, puts them in a better position to succeed in their career. Engagement opportunities provide students with life-changing experiences that: (i) enhance networking connections with professionals who can provide employment references, (ii) give them a chance to gain practical experience by observing and applying the methods and theories learned in classes as well as gain

understanding of the difference between theory and reality, (iii) gain experience in their prospective career paths, (iv) improve their professional communication skills, and (v) gain confidence in their abilities and job prospects.[2,6,8]

College–industry partnerships help produce world-class engineers and technicians who understand the design-, manufacturing-, and business-related activities of various organizations at different levels.[9] As they develop critical analytical skills required to work in industry, students are positioned to become productive team members in their assigned roles after graduation.[10] The benefits of college–industry partnerships on student learning are endless. These experiences help enhance society's development through knowledge transfer and innovation diffusion among students. To make this collaborative effort successful, effective partnerships between students, industry personnel, and course instructors are required. The overall objective of stakeholders should be to graduate professionals with more in-depth knowledge and skills necessary to succeed in this highly competitive world.

College–industry collaboration helps not only students but also industry stakeholders. Industry players are able to hire bright, positive employees with an already developed work ethic.[11] Managers are able to hire professionals who possess the fundamental skills to perform their job, that is, professionals who perform work in a timely and efficient manner, are able to successfully migrate into a team-based environment, and know the importance of completing work initiatives without budget overruns.[12] Surveys conducted by the National Association of Colleges and Employers have shown that communication, honesty, interpersonal, motivation, work ethic, and team skills are the most important qualities employers are looking for when hiring new graduates.[12] If students are involved in industry-based projects as part of their curriculum, they most likely will be able to cultivate these skills. Industry collaboration helps students become active learners through engagement in real-world problems with the expectation that they are responsible for a component of their learning. Such learning helps individuals develop strategies and construct knowledge.[13]

In an active learning environment, the instructor's primary role is to facilitate learning by engaging students in higher order thinking tasks such as analyzing and synthesizing problems, evaluating possible solutions, and making recommendations to deal with those challenges. This approach involves student engagement and requires students to reflect about what they are doing.[14] Cognitive studies have suggested that students learn better when techniques other than lecture are used in the classroom.[13] Other studies have shown that active learning has similar or better effects on student learning when compared with traditional classroom lectures.[14] Hence, it becomes the responsibility of instructors to modify classroom techniques in an effort to increase student learning outcomes and satisfaction. It is important for faculty members to engage in self-reflection and to evaluate their willingness to migrate toward alternative classroom teaching approaches. To promote industry engagement among students, an instructor must act as a liaison to develop and maintain partnerships between industry stakeholders and the institution. Instructors are able to respond to industry needs through the assessment of the curriculum, revising and adding new material to ensure that students are ready for career placement once they graduate and seek employment.[15,16]

This paper outlines some of the necessary elements required to (i) involve industry in the curriculum development process, (ii) enable college-industry partnerships, and (iii) measure the effectiveness of industry collaboration. Case study methodology was used to evaluate the impact of industry engagement in lean manufacturing courses with freshmen and sophomore students in large 4-year engineering and technology programs. The content of this paper is derived from the authors' personal experiences as instructors in such programs.

Purpose and Research Question

The purpose of this study was to examine the learning outcomes of student cognition with regard to industry engagement. Industry engagement is a vital part of engineering and technology courses. Such educational experiences help in producing the next generation work force. Instructors teaching this course enable students to continue learning from real-world experiences. Furthermore, early engagement with industry stakeholders prepares students to focus better on their area of study and be able to relate their classroom experience to industry settings. However, to create next generation experts, instructors are required to identify industry partnerships in close proximity to college campuses and to cultivate important relationships with these partners. This paper further identifies how course instructors develop relationships with industry partners, especially as instructors migrate to new geographical locations.

Methods and Procedure

For this paper, the case study method developed by Yin (2009) was utilized.[17] Qualitative studies are an important way to communicate the perspective of the researchers' approach to the investigation[18] and to articulate research bias and limitations of the study.[19] This case study investigated student learning in a lean manufacturing class that emphasized industry engagement and learning. Instructors incorporated a very effective industry engagement component that included case studies, plant tours, guest speakers, and group projects as part of the course curriculum. Both authors taught multiple sections of this course over a period of 3 years. Course evaluations revealed that students always preferred industry engagement over traditional lectures, and students consistently recommended the continuation of the engagement component. As the authors moved to different institutions and continued to teach similar courses, re-establishment of industry engagement was important to recreate the essence of the course. Being in a new environment created challenges, and the authors utilized various strategies (discussed in later sections) to help build industry relationships.

Case Study

The course in which college–industry partnerships were applied, which used an active learning approach, was a three credit hour lean manufacturing course taught to 200-level students in an industrial technology program. This course exposed students to the concepts of lean as they are applied in manufacturing and service sectors. The concepts taught to students in this specific course were lean principles, lean optimal work for production, and lean management principles.[16] Lean manufacturing courses help students learn about the ways to improve company

performance such as how to identify waste associated with work processes, how to standardize work processes, and how to create smooth flow within the work processes. The overall goal of lean is to reduce any kind of waste that exists in a process. Waste reduction endeavors help improve performance of the company, increase profit margins, increase company competitiveness, and foster higher worker satisfaction.

Teaching of and learning from such a course depend on engagement between local industry and classroom instructors, which is based on an interpersonal approach. Case studies for the course were formulated with industry stakeholders, enabling students to analyze and suggest recommendations. Students completed case studies at the end of relevant units. All case studies were associated with specific course topics and focused on operational inefficiencies faced by collaborative industry partners. The names of the companies were kept anonymous to protect intellectual property. Plant tours to local companies were also conducted and usually concluded with panel discussions. This allowed students an opportunity to engage with industry experts and gain insight about the best practices, current trends, and challenges faced within the organization. Plant tours were targeted to align with concepts taught in the classroom. Virtual plant tours were conducted by utilizing online resources. Such plant tours were limited to 5–10 minute videos that were shown in the classroom immediately following the completion of particular topics. Students were given an opportunity to participate in local lean organizations such as the American Society of Quality monthly meetings. Such venues provided students with an opportunity to learn ways that lean tools were being applied within industry. Participating companies addressed issues faced by the company or tactics used to make a process more efficient. Guest speakers were also invited into the classroom. These guest speakers were from either manufacturing or service industries such as, for example, healthcare or non-profit food banks. They talked about the use of lean practices in their organization. This provided students an opportunity to think beyond the traditional use of lean principles. Students were asked to write a report or reflection about each activity.

Toward the end of each semester, student participated in a 6-week group project with a company of their choice. Students were responsible for completing a team project. Project guidelines were established with the approval of the instructor and industry sponsor. The team of students identified a problem of choice and applied lean tools learned in the course to analyze and solve lean management issues. The students presented their findings in a team presentation and paper (maximum of five pages). The projects were graded by the instructor with the use of a rubric that included a peer-evaluation component. Through evaluations and personal conversations, group projects continued to be identified as one of the most important learning activities by both students and industry stakeholders. Students had an opportunity to work on real-world problems, and industry partners had an opportunity to evaluate students who could become part of their future workforce.

Discussion

Administering activities like those described above are time consuming for the instructor but are also very rewarding. Enhanced learning on the part of the students justifies the efforts required of

the instructors to embed an industry collaboration component. As instructors migrate to new institutions, they can utilize their previously formed contacts to help identify counterparts in new locations (if possible). Instructors can use organizations such as local chapters of the American Society for Quality to form connections with industry partners. Case studies and virtual plant tours from previous classes can easily be used. The instructor can use the departmental contacts at their new institution to establish relationships with new organizations. LinkedIn can be used to actively seek out new industry partners as well. The university center for industrial research and services can be used to find information about local industries. Previous guest speakers can be invited for on-site visits, or they can be asked to be a guest speaker via a webinar. New industry contacts can be developed using contacts made by students as they identify companies to work with for their final project. The instructor can invite representatives from those companies to give presentations to students, which can provide an opportunity to develop more effective college–industry relationships. Previous course instructors can be contacted to learn about practices they used to conduct the course, and industry contacts that may already exist can be secured and maintained. Finally, it is important that instructors understand the official paperwork needed to forge industry partnerships and protect the intellectual property of the institution so that there is no misunderstanding or legal challenges involved.

Conclusion

A strategically important partnership between an educational institution and industry partners is important for teaching engineering, technology, and management students. These partnerships can help instructors develop an integrated curriculum that allows students opportunities to apply concepts learned in the classroom to industry. Such learning helps students gain a better understanding of the core curriculum[2,15] and also helps to prepare an intellectually informed workforce that has an understanding about industrial practices. Instructors play a dynamic role in developing effective partnerships between industry partners and institutions. Instructors need to understand the importance of extending teaching practices beyond the traditional lecture and must strive to develop long-term relationships with industry partners.

Author Bio’s

Dr. Shweta Chopra is an assistant professor in Agricultural and Biosystems Engineering Department at Iowa State University. Her research focuses on measuring effect of industry engagement in student learning, understanding role of lean in healthcare and use of Information and communication technology in food security.

Dr.Kimberly Deranek is an Assistant Professor in the Decision Sciences Department in The H. Wayne Huizenga School of Business and Entrepreneurship at Nova Southeastern. She obtained her PhD in Technology from Purdue University. Her research and teaching interests include the impact of technology on individual and organizational learning; and the effectiveness of technology and continuous improvement initiatives on operational efficiency throughout both manufacturing and service supply chains. Central to her research are technology acceptance theories as well as technology adoption models.

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